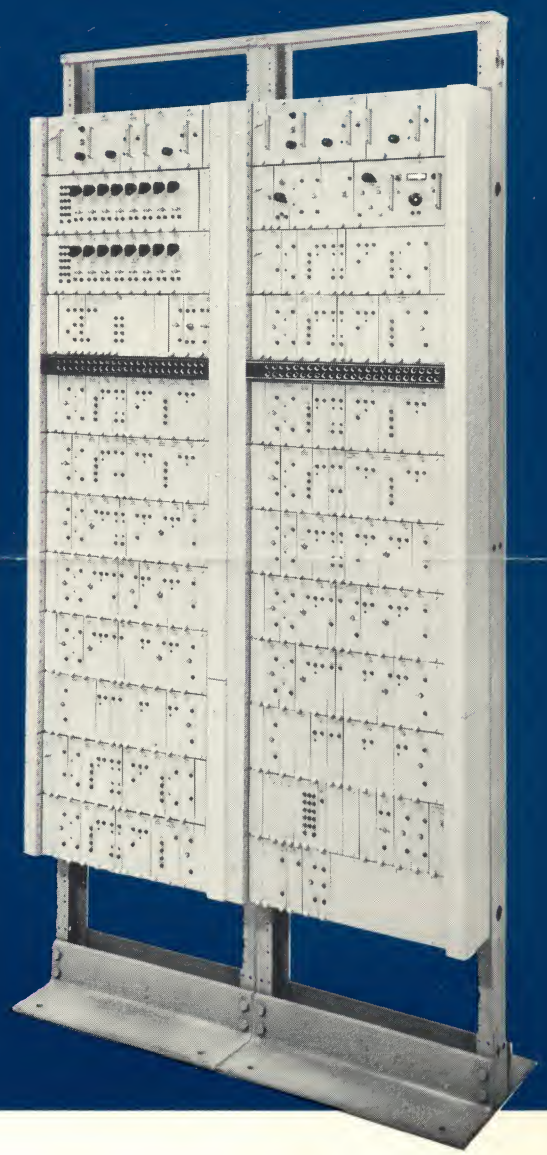
Lenkurt®

27A

DUOBINARY-DATATEL* data terminal for HF radio



The 27A Data Terminal effectively doubles the data-carrying capacity of high-frequency radio circuits. Using Lenkurt's unique Duobinary Coding, combined with dual-diversity reception and proven FSK techniques, the 27A transmits serial data (or digital voice) at 2400 bits per second over a single 3-kc voice channel. Because it is designed expressly for us on HF radio, the 27A offers unusually low error rates despite the fading and interference which are characteristic of such radio links.

HIGH SPEED—The "secret" of transmitting 2400 bits per second within the bandwidth usually required for only half this speed lies in Duobinary Coding, which permits the use of time-proven frequency-shift keying at this high bit rate. This technique effectively doubles the transmission rate of ordinary binary systems — yet it does not suffer the increased error rate and added circuit complexity of a quaternary system.

LOW ERROR RATE—The 27A achieves its low error rate because its susceptibility to intersymbol interference is no higher than that of a binary system operating at only 1200 bps. Furthermore, the 27A has the low noise sensitivity of a ternary system combined with the speed of a quaternary system.

COMPATIBILITY WITH EXISTING EQUIPMENT—The 27A uses the same channel line frequency as older equipment, such as the AN/FGC-29, -60, and -61.

BUILT-IN ERROR DETECTION—The Duobinary system encodes the data in such a way that the signal must follow a predetermined pattern. Thus, certain level transitions are "forbidden," and the optional error detector at the receiver needs only the data stream — no information bits are wasted on error detection alone, and error detection is provided on a *bit-by-bit basis.*

COMPACT—The solid-state design and the printed circuits used throughout make the 27A terminal compact and exceptionally reliable. A full duplex terminal equipped for diversity reception requires only two 19-inch equipment racks 70 inches high.

EASE OF MAINTENANCE—The 27A is designed for unattended operation. Because it does not have the complex circuitry normally associated with multiple-level systems, it does not require the constant attention of skilled maintenance personnel.

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TYPICAL APPLICATIONS

27A applications are as numerous as are the requirements for sending binary information over HF radio. In typical uses, the 27A links business or scientific computers on different continents; or it handles digifax and secure voice communications in digital form for governmental agencies, as well as other forms of digital traffic.

PROVEN PERFORMANCE

The performance of the 27A has been thoroughly proven both in exhaustive field trials and in working applications. Evaluation tests have been performed over a variety of HF links, both trans-Atlantic and trans-Pacific.

For example, in a typical test run the 27A linked two computers over a 2200-mile HF path with microwave extensions. The total route also included Lenkurt 26B Data Modems operating over 200 miles of landline. The transmit computer was programed to send data in blocks, interrogating the receive computer after each block to see whether any errors had occurred. One bit error in a block would cause the computer to retransmit the entire block.

Such an arrangement is common in computer-to-computer service, but even if no errors occur, time is required for interrogation and verification. Thus, the highest theoretical transmission rate is below the actual operating (bit-per-second) speed of the transmission equipment. How far below depends on such things as the length of the data blocks, propagation time of the signal, and program delays in the computers. The amount of retransmission necessary is indicated by how closely this theoretical maximum rate is approached. (A single error in a block requires retransmission of the entire block). The net effective data rate (throughput) represents *completely error-free transmission* for the entire system, including the interconnecting microwave and landline equipment.

In a typical test run (covering several days) the *average* throughput rate was better than 92% of the theoretical maximum speed, while rates as high as 99% were measured. In other words, the effective *error-free* throughput rate exceeded 1700 bps.

In another arrangement, the Duobinary single-bit error-detection capability permits the error detector to stop the transmission as soon as an error occurs, rather than waiting for the end of the data block. This, of course, improves the throughput rate even more.

SYSTEM DESCRIPTION

TRANSMIT — The simplified transmit and receive block diagrams of Figures 1 and 2 indicate the main components of the transmission path. The HF radio transmitter and receivers are included for clarity, although they are not part of the 27A. Incoming serial data at 2400 bps is converted in the serial-to-parallel converter to 16 parallel 150-bps channels. These channels are arranged in two identical groups of 8. Within each group, the channel center frequencies are spaced 170 cps apart from 1785 cps to 2975 cps. With both groups in the upper half of the 3-kc band, no channels suffer the excessive keying distortion which is characteristic when the lower frequencies are keyed directly. Each channel passes through a Duobinary encoder before being applied to a frequency-shift oscillator.

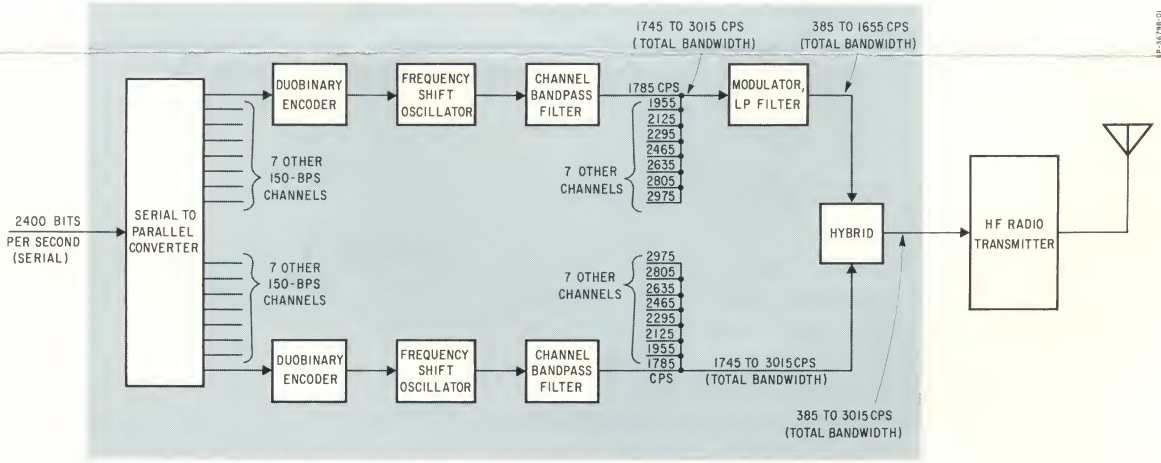

Figure 1. Simplified block diagram of transmit path, including both 27A and HF radio transmitter.

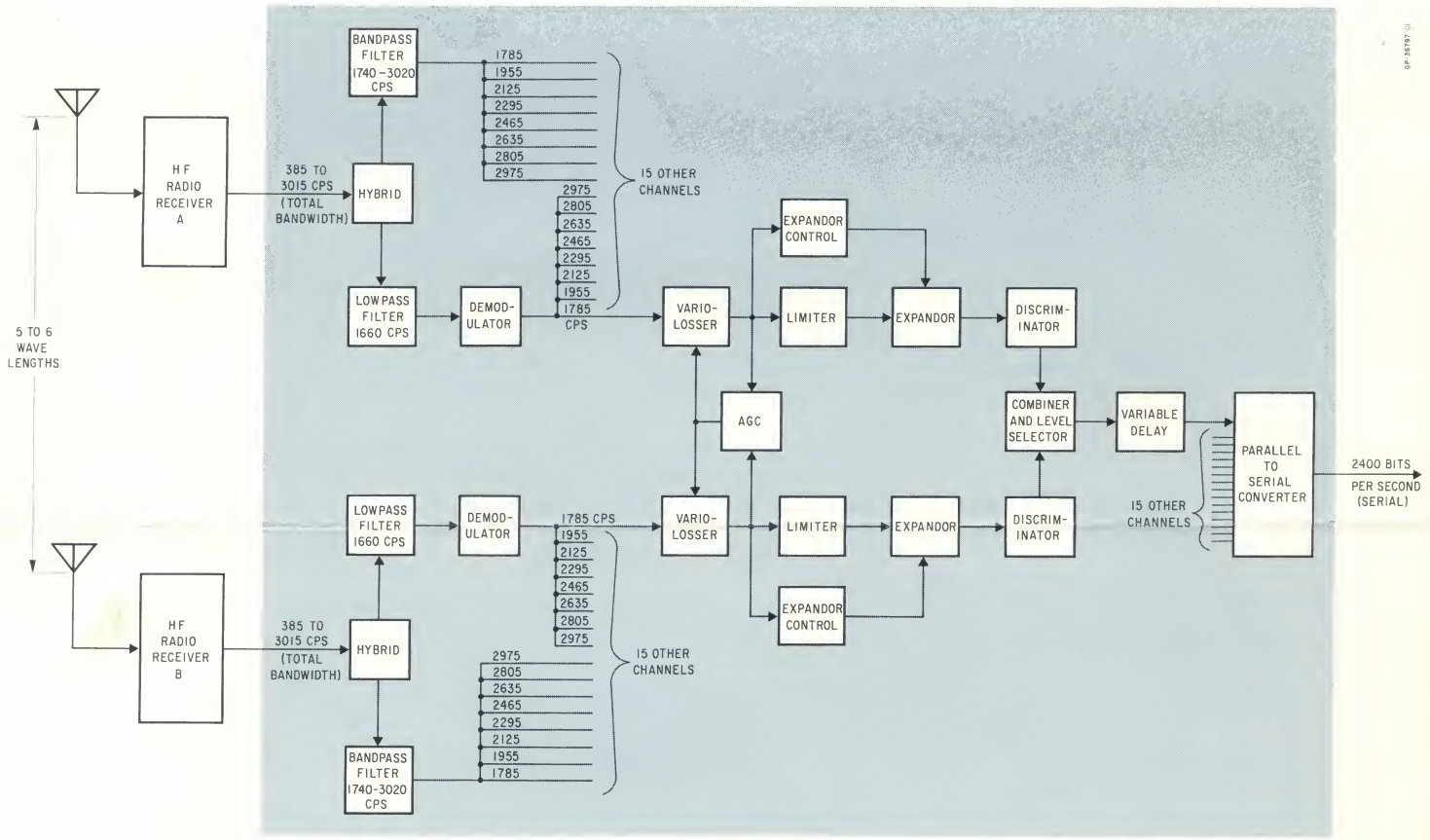

Figure 2. Simplified block diagram of receive path, showing how the 27A combines the reception from two HF radio receivers to combat fading.

After filtering, all 8 channels of each group are combined, and one group is modulated to the 425-1615 cps band in a frequency-division multiplexing arrangement. The two groups are then combined in a hybrid and applied to the radio transmitter.

HF RADIO — While the HF radio link is not part of the 27A, it does form a vital part of the data system. Of course, the quality of radio transmission varies widely, depending on such things as path engineering, time of day, time of year, and solar activity. The better the transmission quality, the better any data system performs. What sets the 27A apart is its ability to provide satisfactory performance over even a poor-quality HF link.

Diversity reception, using two radio receivers with antennas spaced several wavelengths apart, is a standard technique in most HF radio systems. With two slightly different transmission paths, there is no correlation between fading on the two paths.

RECEIVE — The 27A takes its input from both the A and B radio receivers. Each input goes through an identical process. For example, the A input is first divided into two groups of 8 channels, then the low group goes through a demodulator which translates it back to the higher frequency range. The result is two identical 8-channel groups with 170-cps channel spacing from 1785 cps to 2975 cps. Each of the 16 channels in the A path goes to a ratio-squared, post-detection combiner, where it is combined with the corresponding channel from the B path. If the signals from the two receive paths have equal magnitudes, they are added by the combiner. Otherwise, the stronger of the two inputs is enhanced, thus taking full advantage of the diversity reception.

The 16 parallel channels from the combiner go to a variable delay which effectively puts all 16 "in step." That is, it compensates for any variations in transmission time between the parallel channels before they enter the parallel-to-serial converter. The output of the converter is a 2400-bps serial stream.

TIMING SOURCES — The 2400-cps square-wave signals used by the 27A for both transmit and receive timing may be supplied by an external frequency source or by optional clocks available with the equipment.

THE DUOBINARY TECHNIQUE

The exclusive Lenkurt-developed Duobinary Coding technique is the "heart" of the 27A. It is basically a coding process which is designed to retain all information in the input data stream, but *reduce the rate of change* from one information-bearing condition to another. Since it has three levels (the center represents zero, while both the upper and lower represent ones), Duobinary Coding superficially resembles the older ternary system. But the difference is vital — the duobinary system does not allow the signal to go from one extreme level to the other within one bit interval. This reduces the rate of level change, thus decreasing the required bandwidth. The net effect is that a Duobinary system has:

1. The speed of a quaternary system,
2. The minimum susceptibility to intersymbol interference of a non-synchronous binary system operating at only half the speed,
3. The sensitivity to noise of a ternary system.

In addition, the equipment complexity of a Duobinary System is only slightly more than that of a conventional binary FM system. Futhermore, the Duobinary technique provides the "bonus" of error detection without the addition of redundant information bits.

TECHNICAL SUMMARY

TRANSMITTER

Data Input

Rate: 2400 bps (controlled by transmit clock)
Format: Serial binary, NRZ, EIA standard voltage levels

Clock Input

Frequency: 2400 cps ±20 parts per million
Format: Square wave, EIA Standard voltage levels
Phase: Positive edge coincident with data transitions
Stability: ±5 parts in 10^8 per hour

Line Output

Impedance: 600 ohms balanced
Power per channel: −10 dbm nominal (adjustable, −40 to 0 dbm)
Channels: 16, 170-cps center spacing
Signal type: FM
Frequency range: 385 to 3015 cps

RECEIVER

Line Input (two required for diversity operation)
Impedance: 600 ohms balanced
Power per channel: −15 dbm nominal (0 dbm maximum; −30 dbm minimum)
Channels: 16, 170-cps center spacing
Signal type: FM
Frequency range: 385 to 3015 cps

Data Output

Rate: 2400 bps
Format: Serial binary, NRZ, EIA standard voltage levels

Clock Output

Frequency: 2400 cps
Format: Square wave, EIA standard voltage levels
Phase: Positive edge coincident with data transitions
Stability: ±5 parts in 10^8 per hour

POWER REQUIREMENTS (duplex diversity terminal)
Voltage: 117 volts ac ±10%
Current: 3 amperes
Frequency: 50-60 cps

MOUNTING SPACE (duplex diversity terminal)
Two 19-inch equipment racks, 70 inches each.

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